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Report on Generation IV Technical Working Group 3:
Liquid Metal Reactors

Generation IV Roadmap Session
ANS Winter Meeting Reno, NV
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People Involved in this Work

The Membership of Technical Working Group 3

Liquid Metal Reactor

• Stephen Rosen	Co-Chair	South Texas Project (Retired)
• Yutaka Sagayama	Co-Chair	JNC
• Michael Lineberry	Technical Director	ANL
• Charles Boardman		GE (retired); consultant
• Jean-Louis Carbonnier		CEA
• Orlando Joao A. Goncalves		IEN/CNEN
• Jean-Paul Glatz		EURATOM/Karlsruhe
• Do Hee Hahn		KAERI
• Masakazu Ichimiya		JNC
• John Lee		University of Michigan
• Ning Li		LANL
• Claes Nordborg		OECD
• Ronald Omberg		PNNL
• Kune Y. Suh		Seoul National University
• John Tuohy		Burns & Roe
• David Wade		ANL

Reactor System Concepts Submitted

- ***33 concepts from 8 countries submitted; 27 of which were grouped into five sets.***
  - ***concept group A: Medium-to-large sodium-cooled, mixed-oxide fueled reactors with advanced aqueous reprocessing and ceramic pellet or vibratory compaction fabrication (5 concepts)***
  - ***group B: Medium-to-large sodium-cooled, metal-fueled (U-TRU-Zr metal) reactors with electrochemical fuel cycle technology (pyroprocessing) (6 concepts)***
  - ***group C: Medium-sized Pb or Pb-Bi cooled; MOX or Th-U-TRU-Zr metal alloy fueled reactors (one concept had nitride fuel); pyroprocess fuel cycle for the metal-fueled concepts, advanced aqueous or unspecified "dry" process for the ceramic fueled concepts. (9 concepts)***

Reactor System Concepts Submitted cont.

- *group D: Small, Pb or Pb-Bi cooled; metal or nitride fueled reactors with long-life "cartridge" or cassette cores. Fuel cycles vary. (4 concepts)*

- *group E: Sodium-cooled concepts that eliminate the traditional secondary sodium loops by development of novel new steam generators. (3 concepts)*

- *Four concepts rejected, one evaluated stand-alone, (Russian SVBR System) and one was essentially a set of principles (SCNES) to be folded into group A (and possibly B).*

Technical Features

- ***Fuel cycle technology in the great majority of cases was the "pyroprocess" (i.e. electrometallurgical technology) or the "advanced aqueous process"***
  - ***both aim to avoid plutonium separation***
  - ***both will require extensive development***
- ***Fuel fabrication***
  - ***for pyroprocess: remote metal casting***
  - ***for advanced aqueous: remote pellets or remote vibro-pack***
- ***Fuels***
  - ***mixed oxide (reference or backup in 10 concepts)***
  - ***metal (16 concepts)***
  - ***nitride (6 concepts)***
- ***Coolants:***
  - ***sodium (11 concepts)***
  - ***lead or lead-bismuth eutectic (14 concepts)***
- ***Sizes: from 75 MWe to 1500 MWe***
- ***Safety: general attempt to rely on inherent safety features; design features vary greatly.***

The Evaluation Thus Far

- ***"Screened for Potential"; the concept groups and stand-alone concept evaluated for potential to meet the Gen IV goals***
  - ***sustainability***
  - ***safety and reliability***
  - ***economics***
- ***Status of technologies evaluated***
  - ***each concept group, and***
  - ***"base technologies": fuels, coolants, fuel cycle***
- ***Preliminary look taken at R&D requirements***

Liquid Metal Reactor Systems and the Gen IV Goals

- ***Uranium resource utilization in a category by itself compared to all thermal systems.***
- ***Significant waste volume reduction relative to ALWR once-through, but the key benefit would derive from meeting the widely-adopted goal of 99.9% recycle of all actinides.***
  - ***greatly eases the technical requirements on repositories.***
- ***Many of the systems claim immunity (i.e. no fuel damage) to ATWS events.***
- ***Proliferation - resistance evaluation is challenging***
- ***Economics: the great challenge, being approached through simplification of both reactors and fuel cycle facilities.***
  - ***smaller footprint***
  - ***less commodities***
  - ***reduced nuclear safety-grade equipment***
  - ***modularity***

The Road Ahead

- ***TWG 3 specifying needed R&D along three “tracks”***
  - ***group A = track A***
  - ***group B = track B***
  - ***group C & D = track C***
- ***Track C is more science-based, for lead or lead-bismuth coolant, emphasizing fundamental feasibility issues (e.g. coolant/structure compatibility; high temperature materials, etc.).***